What is the contribution of biogenic volatile organic compound emissions to ambient levels of ozone and particulate matter?

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research and development

Science Questions

- What are the rates of biogenic emissions from different vegetative sources and how do they vary by season, time of day, and geographic location?
- What is the size distribution and chemical composition of fine PM emissions from open burning and how do these emissions vary temporally (i.e weekly) and spatially (1-20km, county)?

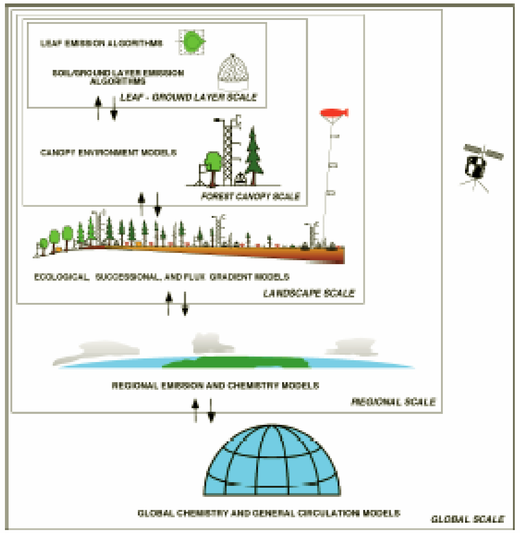
Research Goal

To develop data and models that allow states and Regions to develop accurate emissions inventories of biogenic and other natural source emissions to support development of effective air pollutant attainment strategies.

Methods/Approach

Biogenic volatile organic compounds (BVOCs) are emitted from natural and agricultural sources such as forests and crops. Typically very reactive, BVOCs are considered to be important factors in determining air quality in many regions of the United States. Although they are not usually considered as pollutants, BVOCs often react with anthropogenic emissions of nitrogen oxides (NOx) to form ozone. Therefore, air quality models require accurate emission estimates of BVOCs. Emission models are constructed from data collected at leaf to plant levels, and then "scaled up" to regional and global levels as shown below.

HIERARCHY OF METHODS AND MODELS USED IN BIOGEOCHEMICAL CYCLING RESEARCH

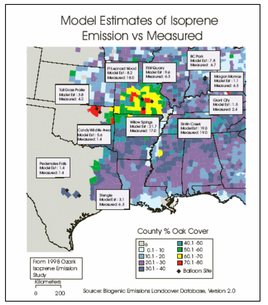


Major vegetation species are tested for BVOC emissions rates under a range of sunlight, temperature, and humidity levels. In the United States, BVOC emissions are dominated by isoprene from oak and poplar trees, terpenes from conifers, and oxygenated compounds from crops and grasslands.

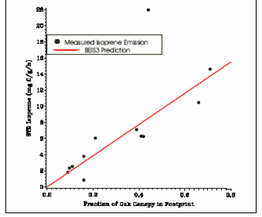
Vegetation enclosures and portable field instrumentation allow us to test dominant plant species for emission rates of various BVOCs. By measuring emissions non-destructively in the plant's natural environment, we can develop more realistic emission factors for these compounds under a range of environmental conditions.

Tethered balloons are used to deploy meteorological sensors and trace gas sampling cartridges (below). Atmospheric concentrations of BVOCs are used to estimate emissions on scales of 100 km^2, which are useful for model comparisons.

Results/Conclusions

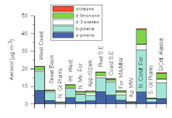


Although data from this study are still being analyzed, results thus far indicate that emission models capture the variability in isoprene emissions measured by aircraft and tethered balloons quite well. Model estimates and measured emission comparisons at individual sites within the study region are shown above. The magnitude of these emissions also agrees quite well with model estimates, also illustrated graphically below.



Conclusions

EPA biogenic emission models and inventories are important in determining natural contributions to ambient VOC levels and reactivity. Model estimates for the Central U.S. compare favorably with real-world data from a high-isoprene source region in and around the Ozark Mountains. This has also been demonstrated in the southeastern U.S. Further research is being conducted to develop and improve components of the modeling system which account for BVOCs that form aerosols upon reaction with other atmospheric compounds. These compounds include monoterpenes and other compounds which can form organic aerosols. Preliminary results, shown below, suggest that under certain conditions, aerosols composed of BVOC reaction products can account for significant atmospheric loadings.



Future Directions

- Integrate field research and laboratory findings into EPA's biogenic emission modeling systems.
- Update isoprene emission mechanism in BEIS3 to account for leaf growth as well as for the effect of temperatures and sunlight
- Update vegetation data base that underlies BEIS3 to include more recent crop census information.
- Produce improved emission factors for monoterpenes and sesquiterpenes for BEIS3 to enable improved modeling of secondary aerosol formation (SOA) of BVOC emitted compounds
- Develop predictive models and scenarios that will enable us to evaluate prescribed and wildfire emissions given different prescribed burning programs

Impact and Outcomes

- More accurate biomass burning chemical tracers for the fuels that are most abundantly consumed in biomass open burning. These have been shown recently to improve source apportionment models for this source.
- Revised emission factors for forest and agricultural fuels.
- ORD Studies have clearly demonstrated that biogenic compounds are emitted in large enough quantities to impact air quality policy decisions in the U.S.
- ORD has worked with its federal partners and university scientists to produce high quality emissions models that are used to generate inventories and as inputs to air quality models that predict future PM and ozone concentrations.
- EPA's BEIS3 model output has been tested against actual emissions data and they compare reasonably well.

Air Quality